
Space Weather Technical Forecast

Issued on Sunday 29 December 2024 at 01:17 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: R1/R2 Radio Blackouts Expected Days 1-4.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity at GOES16 has been Moderate, with three isolated M-flares, with a peak flare of M4.5 at 28/1121 UTC from AR3932 in the southwest. The other main sources of flare activity over the past 24 hours are AR3933 and AR3936, both in the western hemisphere, AR3928 in the northeast, and new or returning regions approaching the solar equatorial eastern horizon.

There are currently twelve sunspot regions on the disc, one of which is unnumbered. There are four regions of significance due to their complexity. AR3936 (Ekc/Beta-Delta), in the northwest disc remains the largest and most complex region. AR3932 (Dai/Beta-Delta) in the southwest still appears to show a possible weak delta spot in the trailing section, the lead portion has almost entirely faded to plage with the group only retaining bipolar status due to the presence of this small delta. AR3928 (Dso/Beta-Delta), to the south of AR3933, has seen significant fading of its trailing portion and is similarly trending towards a complex unipolar group, although there still appears to be a faint delta spot to the rear of the lead portion. AR3938 (Dsc/Beta-Gamma) in the northeast shows a fairly compact north-south configuration. AR3939 (Csi/Beta) and AR3941 (Csi/Beta), both in the southeast, have developed a number of intermediate spots during the UTC afternoon of 28 Dec. AR3940 (Axx/Alpha) has faded to plage. The remaining regions are relatively small, simple and mostly unchanged.

Numerous CMEs have been observed leaving the disc on SOHO LASCO imagery over the past 24 hours. However, these are considered to have been far-sided in origin. No Earth-directed CMEs have been observed leaving the solar disc in the past 24 hours. A filament eruption and dimming event was observed on GONG H-alpha imagery in the vicinity of AR3939 around 28/1900 UTC, although it is uncertain if the ejecta produced a CME.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR showed a slow regime, with background solar wind speeds initially 280-300km/s. Around 28/1300 UTC solar winds saw a gradual increase to around 350km/s. Density was largely below average, although there was a sustained period of Average to slightly Above Average levels 28/1740-2130 UTC with a peak of 18ppcc. The Interplanetary Magnetic Field (IMF) was weak throughout. The north-south component remained weak but erratic, fluctuating between +4/-3nT. Phi angle was mostly negative (towards the Sun), although was positive (away from the Sun) 28/0221-0450 UTC.

The net result of the above solar wind measures was Quiet geomagnetic activity throughout (Kp 0-1).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained at background throughout, well below the S1/Minor Radiation Storm threshold.

High energy electron flux (greater than 2MeV) at GOES16 was at Moderate levels, peaking at 28/1620 UTC at 590pfu. The associated 24-hour fluence was below the Active ($1e8$ integrated flux) threshold on a slightly declining trend. The 29/0001UTC observation was $1.78e7$ integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Occasional M-class flares are Expected, with a Slight Chance of isolated X-class flares throughout. The arrival of one or more significant active regions across the eastern horizon during the period slightly increases the risk of more frequent and significant flare activity.

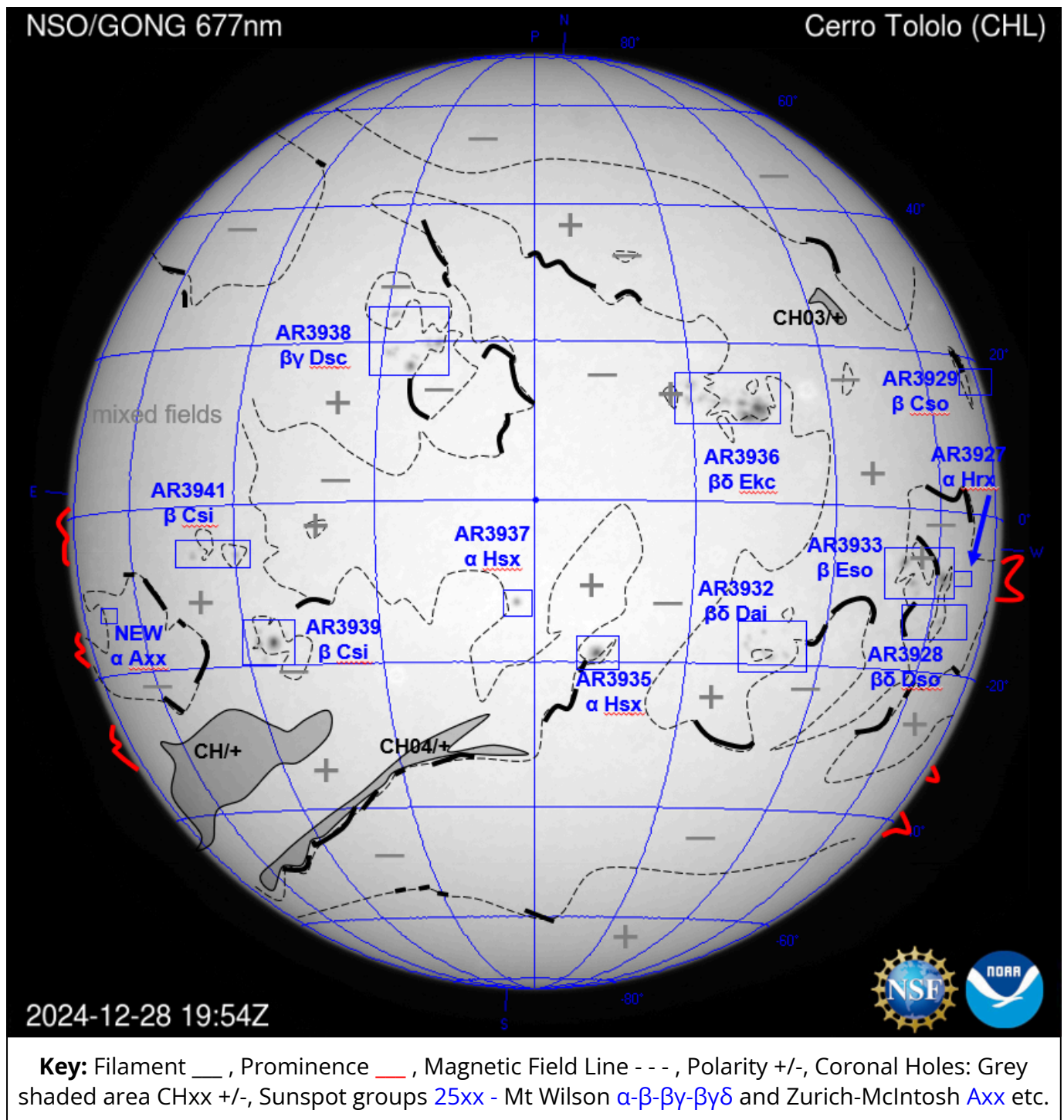
Solar Wind / Geomagnetic Activity: No coronal hole fast winds nor CMEs currently feature in the forecast. Any coronal holes on the disc are not expected to have any influence on wind speeds nor geomagnetic activity. Confidence remains low in the possibility of any glancing blows from CMEs during the period due to the weight of numbers of recent CME events across the whole Sun.

Geomagnetic activity is expected to be mainly Quiet (Kp 0-2), but with a Slight Chance of Unsettled to Active (Kp 3-4) intervals should any glancing CME effects occur - perhaps more probable on Days 3-4 (31 Dec - 01 Jan).

Energetic Particles / Solar Radiation: There is a Slight Chance of S1/Minor Radiation Storm or greater enhancements during the period, this risk slightly increases later in the period as the larger groups rotate into a more favourable position.

Electron flux levels remain Moderate but are expected to gradually ease into the period in the absence of any enhancement.

Figure 1: Solar Synoptic map valid 28/2000 UTC



Geomagnetic Storms

No CMEs or coronal hole fast winds are expected to arrive at Earth during the forecast period.

In recent days several CMEs were analysed as passing close to the Earth-Sun line and present a very slight risk of minor glancing enhancements during Day 1 (29 Dec), but perhaps more probable later Day 3 into Day 4 (31 Dec-01 Jan). Geomagnetic activity is expected to remain Quiet (Kp 0-2), although these close passes have the potential to produce isolated Unsettled to Active intervals (Kp 3-4). This is considered low confidence and a low probability.

The current southern hemisphere far-side is proving a fertile breeding ground for CMEs, with those observed over recent days mostly headed southeast from the far-side, implying the presence of a large and active region here - potentially of note as a source for geomagnetic activity into the New Year period, but likely beyond the scope of this forecast period.

Solar winds are currently around 350 km/s and are expected to remain at background levels. A rise to Slightly Elevated levels is possible should any CMEs pass close to the Earth during the period. MOSWOC Enlil output included an uncertain and erroneous HSS that continues to influence the modelled wind speeds at the beginning of the period, values appear to trend towards expectations later in the period. MOSWOC SWPM is perhaps providing a better steer for the trend of winds, although values are still considered to be about 100 km/s too high.

Geomagnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC Enlil. Considered poor guidance for much of the period, although wind speeds likely to come in line with reality around 30 Dec.

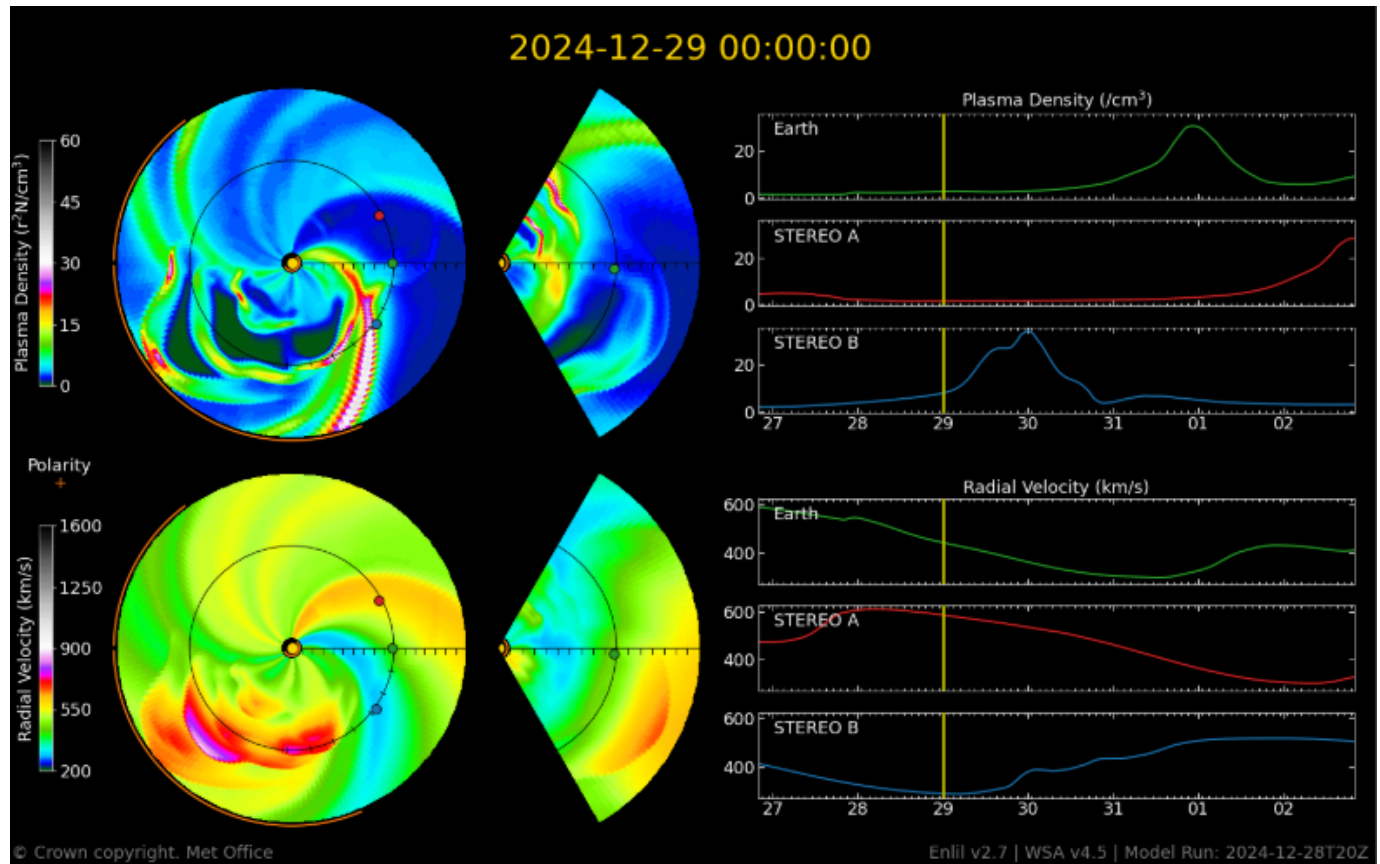
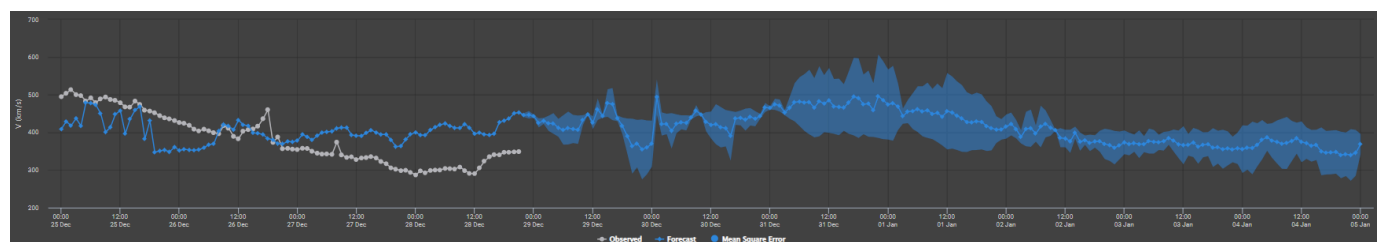


Figure 3: MOSWOC SWPM. The overall trend of forecast values is considered reasonable although wind speeds are around 100km/s too fast.



Radio Blackouts - X-Ray Flares

The Penticton 10.7cm flux has been on a rising trend in recent days as the number of larger sunspot regions has increased, reaching a peak for this rotation. Values showing sign of some stabilisation.

Recurrence suggests the potential for further sunspot regions to round the eastern limb during the period, with this supported by recent far-side CME activity. Although far-side sounding output is not showing any significant regions (likely due to their proximity to the limb where soundings have a minimum ability to detect such regions) limb flux looping and coronagraph imagery suggests the presence of regions approaching the limb. None of the four sunspot regions of note are expected to rotate off of the disc during the forecast period, although AR3933 and AR3928 will lie close to the western limb.

The assessment of any new regions notwithstanding, flare risk looks to remain elevated during the period and occasional M-class flares remain Expected, with a Slight Chance of X-class flares maintained throughout pending further developments. The risk is considered to increase slightly later in the period based on the consideration of the aforementioned new or returning regions.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	80	80
Very Active	R3-R5 (X Class)	No	10	10	10	15

Figure 4: GOES16 and GOES18 X-ray irradiance trace for the past 24-hours.

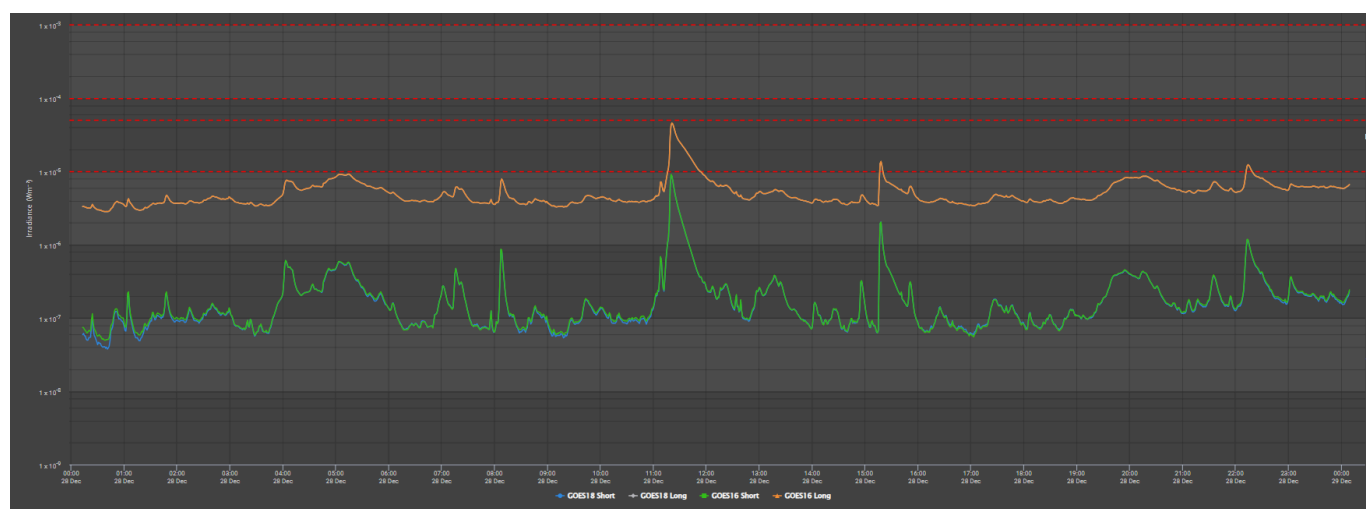
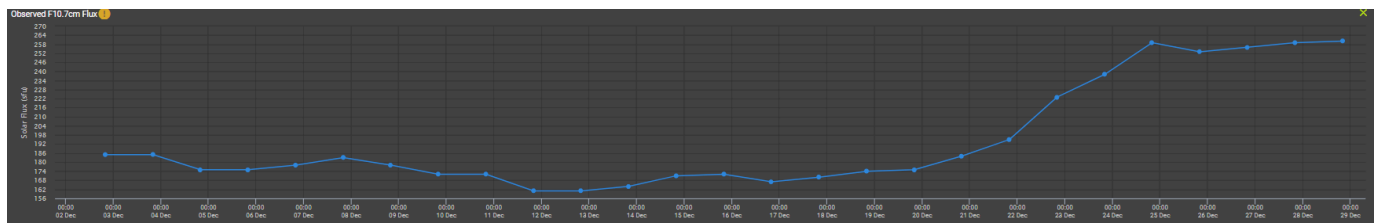


Figure 5: 27-day observations of Penticton F10.7cm flux.

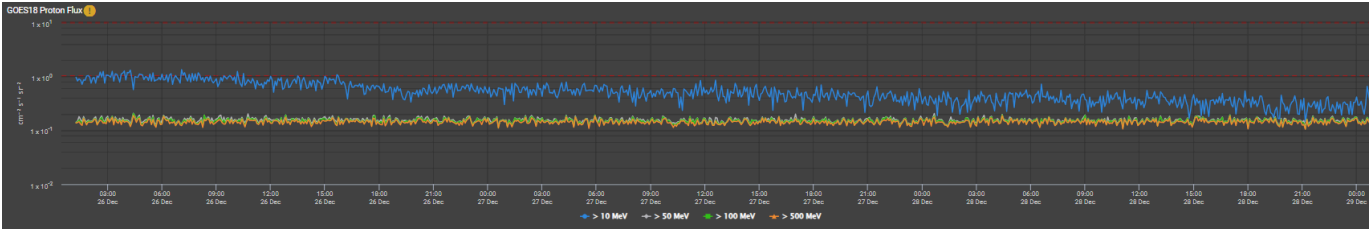
Solar Radiation Storms (High Energy Protons)

High energy proton counts remain at background values. There remains a Slight Chance of S1/Minor Solar Radiation storms (or greater) should any significant flares occur from the larger regions on the disc as they rotate into more favourable locations for connection with Earth.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	10	15	15	15
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

Figure 6: GOES18 Proton Flux for the last 3-days.



High Energy Electrons ($\geq 2\text{MeV}$)

High energy electron flux has remained at Moderate levels in the last 24 hours. A steady state diurnal oscillation is expected through the period with a slightly declining trend towards background. With no further drivers to increase electron populations, fluence will now most likely remain below Active throughout. MOSWOC REFM is now showing a steady forecast through the next three days, which is considered good guidance.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1 \times 10^8$	No	5	5	5	5
Very Active	$\geq 2\text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 7: GOES16 Electron Flux over the past 3-days.

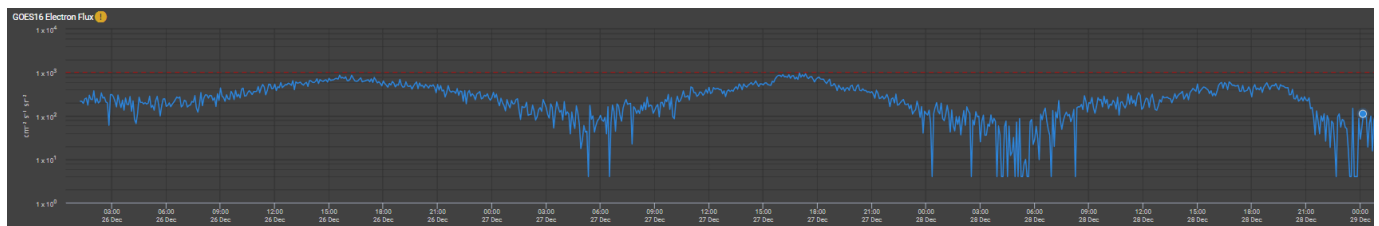


Figure 8: MOSWOC REFM. Trend of forecast values accepted.

